

10/579682

THE UNITED STATES PATENT AND TRADEMARK OFFICE
IN THE RECEIVING OFFICE THEREOF

10/579682 PCT/IL 17 MAY 2006

In re International Application of:

Applicants : Lucid Information Technology, Ltd. et al.
International Application No.: PCT/IL2004/001069
International Filing Date : November 19, 2004
Title of Invention : METHOD AND SYSTEM FOR MULTIPLE 3-D GRAPHIC
PIPELINE OVER A PC BUS
Attorney Docket No. : 142-002PCT000
Authorized Officer : Kee M. Tung

Honorable Commissioner of Patents
and Trademarks
Washington, D.C. 20231

REPLY TO WRITTEN OPINION

SIR:

Applicants submit herewith the following remarks in reply to the Written Opinion mailed in the International Application on July 15, 2005.

Applicants have amended the Claims under Article 34(2)(b) in order to avoid any basis for rejection on formal grounds under the PCT Rules, and more clearly define over the prior art of record.

U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al discloses a system which has multiple graphics pipelines and supports only image division parallelization, wherein each pipeline's device driver controls the entire video display or a discrete region thereof. As disclosed, this system can also accommodate multiple video displays, each controlled by separate device driver.

U.S. Letters Patent No. 7,757,385 to Narayanaswami et al discloses a system which only supports image division parallelization, wherein rendering occurs across multiple processors by pixel location or by display region. Allocation may be dynamic such that a particular pixel or display region may be processed by a first processor for a period of time, and then rendered by a second processor for another period of time.

Also, Molner's article "PixelFlow: High-Speed Rendering Using Image Composition" discloses a system which supports only object division parallelization, separately from image division (i.e. screen subdivision) parallelization.

However, none of these prior art references disclose, teach or suggest, singularly or in combination, a system employing a graphics processing architecture, wherein a graphic hub is arranged between the system's I/O module and a plurality of graphical processing units (GPUs), as claimed.

Furthermore, none of these prior art references disclose, teach or suggest such a system that supports object division, image division and time division modes of GPU parallelization, over time or over clusters of GPUs, and which are dynamically managed according to the graphics work-load encountered by the system during graphic processing and image display operations.

Thus, Applicants firmly believe that U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al., U.S. Letters Patent No. 7,757,385 to Narayanaswami et al., and publication "PixelFlow: High-Speed Rendering Using Image Composition" by Molnar et al., singularly, and in combination with each other, fail to disclose, teach, or otherwise suggest the system of Claim 1 for improving the parallelization of image processing, using one or more parallelization modes, wherein said image that is displayed on at least one computer screen by one or more Graphic Processing Units (GPUs), and having:

- a. one or more software applications, for issuing graphics commands;
- b. one or more graphic libraries, for storing data used to implement said graphics commands;
- c. one or more Software Hub Drivers, for controlling a Hardware Hub, for interacting with the operation system of said computer and said graphic libraries, for performing real-time analysis of a data stream, from which frames of said image are generated, for determining the parallelization mode of each GPU, and for forwarding said data stream or a portion thereof to each GPU;
- d. one or more GPU Drivers, for allowing said GPUs to interact with said graphic libraries; and
- e. at least one I/O module for interconnecting between said Software module and said Hardware Hub,

wherein, said Hardware Hub distributes, for each frame, between said GPUs, graphic commands and said data stream or a portion thereof, and composites a graphics output for display, using the outputs obtained from at least one GPU, while reconfiguring, whenever required, said parallelization mode of each said GPU, for said each frame.

Applicants also firmly believe that U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al., U.S. Letters Patent No. 7,757,385 to Narayanaswami et al., and publication "PixelFlow: High-Speed Rendering Using Image Composition" by Molnar et al., singularly, and in combination with each other, fail to disclose, teach, or otherwise suggest the method of Claim 8 for improving the parallelization of image processing, using one or more parallelization modes, wherein said image that is displayed on at least one computer screen by one or more Graphic Processing Units (GPUs), and having:

- a. providing one or more software applications, for issuing graphics commands;
- b. providing one or more graphic libraries, for storing data used to implement said graphics commands;
- c. providing one or more Software Hub Drivers, for controlling a Hardware Hub, for interacting with the operation system of said computer and said graphic libraries, for performing real-time analysis of a data stream, from which frames of said image are generated, for determining the parallelization mode of each GPU, and for forwarding said data stream or a portion thereof to each GPU; and
- d. providing one or more GPU Drivers, for allowing said GPUs to interact with said graphic libraries.
- e. providing at least one I/O module for interconnecting between said Software Hub Drivers and said Hardware Hub; and
- f. for each frame, distributing between said GPUs and by means of said Hardware Hub, graphic commands and said data stream or a portion thereof, and compositing a graphics output for display, using the outputs obtained from at least one GPU, while reconfiguring, whenever required, said parallelization mode of each said GPU, for said each frame.

Applicants also firmly believe that U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al., U.S. Letters Patent No. 7,757,385 to Narayanaswami et al., and publication "PixelFlow: High-Speed Rendering Using Image Composition" by Molnar et al., singularly, and in combination with each other, fail to disclose, teach, or otherwise suggest the computer system of Claim 16 capable of displaying images of 3-D objects modeled within computer system, and having:

- (1) an operating system (OS);
- (2) an I/O module;
- (3) a graphics processing subsystem interfaced with said I/O module;
- (4) one or more software applications for generating a stream of geometrical data and graphics commands supporting (i) the modeling of an object having 3D geometrical characteristics

and (ii) the viewing of images of said object during an interactive process between said computer system and a user thereof;

(5) one or more graphic libraries for storing data used to implement said stream of geometrical data and graphics commands;

(6) at least one display surface for displaying said images by graphically displaying frames of pixel data produced by said graphics processing subsystem; and

said graphics processing subsystem including:

(a) a plurality of Graphic Processing Units (GPUs) arranged in a parallel architecture and operating according to one or more parallelization modes of operation so that each said GPU is allowed to process data in a parallel manner on the time, image and object domains, said one or more parallelization modes of operation including (i) a time division mode wherein each GPU renders a different frame of pixel data to be displayed at a different moment of time, (ii) an image division mode wherein each GPU renders a subset of the pixels used to compose each frame of pixel data to be displayed, and (iii) an object division mode wherein the object which is to be displayed as a frame of pixels, is decomposed into said stream of geometrical data and graphic commands which are distributed to said GPUs for rendering the frames of pixel data compositing the images to be displayed on said at least one display surface, wherein said frames of pixel data are (i) generated by said GPUs processing the stream of geometrical data and graphical commands while operating in one or more of said parallelization modes, and (ii) displayed on said at least one display surface by one or more of said GPUs;

(b) a Hardware Hub, interfacing with said I/O module and with said GPUs, for distributing the decomposed stream of geometrical data and graphic commands among said GPUs, compositing pixel data output from said GPUs for display according to different parallelization modes, and managing said parallelization mode of each said GPU in the parallel architecture;

(c) one or more software hub drivers, installed on said computer system, (1) for performing the following functions: (1) controlling said hardware hub, (2) interacting with the OS and said graphic libraries, (3) performing real-time analysis of said stream of geometrical data and said graphics commands, from which frames of said pixel data are generated, (4) determining the parallelization mode of each said GPU, and (5) forwarding said graphical commands and said geometrical data stream or a portion thereof to each said GPU; and

(d) one or more GPU drivers, installed on said computer system, for allowing said GPUs to interact with said graphic libraries;

wherein, for each image of said object to be generated and displayed, said hardware hub distributes between said GPUs, said graphic commands and said stream of geometrical data or a portion thereof, and composites a pixel data output using the pixel data outputs obtained from at least

one said GPU, so as to generate a corresponding frame of pixel data to be displayed on said at least one display screen.

Applicants also firmly believe that U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al., U.S. Letters Patent No. 7,757,385 to Narayanaswami et al., and publication "PixelFlow: High-Speed Rendering Using Image Composition" by Molnar et al., singularly, and in combination with each other, fail to disclose, teach, or otherwise suggest the method of Claim 27 of generating frames of pixel data of an object for display using a computer system including (1) an operating system (OS), (2) an I/O module, (3) one or more software applications for generating a stream of geometrical data and graphics commands supporting (i) the modeling of an object having 3D geometrical characteristics and (ii) the viewing of images of said object during an interactive process between said computer system and a user thereof, (4) one or more graphic libraries for storing data used to implement said stream of geometrical data and graphics commands, and (5) at least one display surface for displaying said images by graphically displaying frames of pixel data produced by said graphics processing subsystem, and having:

- (a) interfacing a Hardware Hub with said I/O module;

- (b) interfacing with said hardware hub, a plurality of Graphic Processing Units (GPUs) arranged in a parallel architecture and operating according to one or more parallelization modes of operation so that each said GPU is allowed to process data in a parallel manner on the time, image and object domains, said one or more parallelization modes of operation including (i) a time division mode wherein each GPU renders a different frame of pixel data to be displayed at a different moment of time, (ii) an image division mode wherein each GPU renders a subset of the pixels used to compose each frame of pixel data to be displayed, and (iii) an object division mode wherein the object which is to be displayed as a frame of pixel, is decomposed into said stream of geometrical data and graphic commands which are thereafter distributed to said GPUs for rendering the frames of pixel data compositing the images to be displayed on said at least one display surface, and each said GPU having a corresponding frame buffer for storing a frame of pixel data generated by said GPU;

- (c) installing within said computer system, one or more software hub drivers, for performing the following functions: (1) controlling said Hardware Hub, (2) interacting with said OS and said graphic libraries, (3) performing real-time analysis of said graphic commands and said geometrical data stream, from which frames of pixel data are generated, (4) determining the parallelization mode of each GPU, and (5) forwarding said graphic commands and said geometrical data stream or a portion thereof to each GPU;

- (d) installing within said computer system, one or more GPU Drivers, for allowing said GPUs to interact with said graphic libraries;

(e) for each image of said object to be generated and displayed, said Hardware Hub distributing between said GPUs, said graphic commands and said stream of geometrical data or a portion thereof, said GPUs processing the stream of geometrical data and graphical commands while operating in said one or more of said parallelization modes, and compositing a pixel data output using the pixel data outputs obtained from at least one said GPU, so as to generate a corresponding frame of pixel data to be displayed on said at least one display screen.

Applicants also firmly believe that U.S. Letters Patent No. 5,745,762 to Celi, Jr. et al., U.S. Letters Patent No. 7,757,385 to Narayanaswami et al., and publication "PixelFlow: High-Speed Rendering Using Image Composition" by Molnar et al., singularly, and in combination with each other, fail to disclose, teach, or otherwise suggest the graphics processing subsystem of Claim 33 for use in a computer system capable of displaying images of 3-D objects modeled therewithin, and having:

(1) an operating system (OS);

(2) an I/O module;

(3) one or more software applications for generating a stream of geometrical data and graphics commands supporting (i) the modeling of an object having 3D geometrical characteristics and (ii) the viewing of images of said object during an interactive process between said computer system and a user thereof;

(4) one or more graphic libraries for storing data used to implement said stream of geometrical data and graphics commands;

(5) at least one display surface for displaying said images by graphically displaying frames of pixel data produced by said graphics processing subsystem, and said graphics processing subsystem comprising:

(a) a plurality of Graphic Processing Units (GPUs) arranged in a parallel architecture and operating according to one or more parallelization modes of operation so that each said GPU is allowed to process data in a parallel manner on the time, image and object domains, wherein frames of pixel data for display on said display surface are (i) generated by said GPUs processing the stream of geometrical data and graphical commands while operating in one or more of said parallelization modes, and (ii) displayed on said at least one display surface by one or more of said GPUs;

(b) a Hardware Hub, interfacing with said I/O module and with said GPUs, for distributing the decomposed stream of geometrical data and graphic commands among said GPUs, compositing pixel data output from said GPUs for display according to different parallelization modes, and managing said parallelization mode of each said GPU in the parallel architecture;

(c) one or more software hub drivers, (1) for performing the following functions: (1) controlling said Hardware Hub, (2) interacting with the OS and said graphic libraries, (3) performing real-time analysis of said stream of geometrical data and said graphics commands, from which frames of said pixel data are generated, (4) determining the parallelization mode of each said GPU, and (5) forwarding said graphical commands and said geometrical data stream or a portion thereof to each said GPU; and

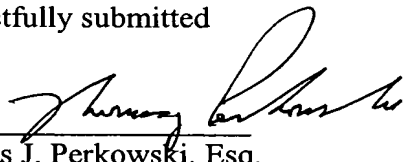
(d) one or more GPU drivers, installed on said computer system, for allowing said GPUs to interact with said graphic libraries; and

wherein, for each image of said object to be generated and displayed, said Hardware Hub distributes between said GPUs, said graphic commands and said stream of geometrical data or a portion thereof, and composites a pixel data output using the pixel data outputs obtained from at least one said GPU, so as to generate a corresponding frame of pixel data to be displayed on said at least one display screen.

In view of the remarks set forth above, Applicants respectfully request favorable reconsideration.

The Commissioner is hereby authorized to charge any fee deficiencies to Deposit Account 16-1340.

Respectfully submitted



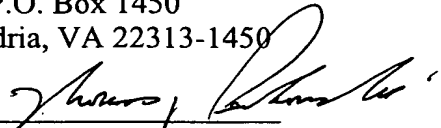
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